4.5. Storm Water Runoff Management

Management Measure for Storm Water Runoff:

Implement effective runoff control strategies that include the use of pollution prevention activities and the proper design of hull maintenance areas.

Reduce the average annual loadings of total suspended solids (TSS) in runoff from hull maintenance areas by 80 percent. For the purposes of this measure, an 80 percent reduction of TSS is to be determined on an average annual basis.

Management Measure Description

Any debris that is on the ground and light enough to be swept away by flowing rainwater or snowmelt can end up in lakes, reservoirs, ponds, rivers, streams, canals, bays, estuaries, or oceans. Sanding dust, paint dust and chips, copper and other heavy metals, and other such solids that are carelessly or inadvertently allowed to drop to the ground while maintaining or repairing a boat by sanding, pressure washing, or other abrasive methods can be swept up by the runoff of the next rainstorm. Oils, grease, solvents, paint drippings, and fuel spilled or dripped onto the ground can also be carried away in the runoff. Unless the runoff is controlled or treated in some manner, all of these pollutants end up in the marina basin, where they create unsightly surface films or float until they adhere to surfaces like boat hulls or docks. Some of these pollutants flow dissolved in runoff or attached to soil carried by the runoff. When they reach the marina basin, they sink with the soil to the bottom, are eaten by bottom-feeding fish or by filter-feeding shellfish, or settle onto the leaves of aquatic vegetation and clog their pores. Storm water that is treated in some way to remove these pollutants before they can reach the marina basin does not result in these problems.

The National Pollutant Discharge Elimination System (NPDES) was established to control pollutant discharges to the nation's waters, including those from storm water runoff. The 1987 amendments to the Clean Water Act mandated EPA to develop a tiered implementation strategy for the NPDES Storm Water Program. In response to the 1987 Amendments, EPA developed Phase I of the NPDES Storm Water Program in 1990. Phase I requires NPDES permits for storm water discharges from

- "Medium" and "large" municipal separate storm sewer systems (MS4s) that serve or are located in incorporated places or counties with populations of 100,000 or more people.
- Eleven categories of industrial activity, one of which is construction activity that disturbs 5 acres or more of land.

The 11 categories of industrial activities for which storm water discharge permits are required are defined at 40 CFR 122.26(b)(14). A permit is required for Standard Industrial Classification (SIC) codes 4493 (marinas) and 3732 (boatyards and boat builders that repair, clean, and/or fuel boats). Note that the North American Industry Classification System (NAICS) is replacing the U.S. SIC system and is scheduled to be completed by 2002. NAICS was developed jointly by the United States, Canada, and Mexico to provide new comparability in statistics about business activity across North America. NAICS numbers corresponding to the previous SIC numbers are provided in Table 4-2.

Table 4-2. Conversion of SIC to NAICS.

SIC		NAICS	
3732	Boat Building and Repairing		
	Boat Repair	81149	Other Personal and Household Goods Repair and Maintenance (part)
	Boat Building	336612	Boat Building
4493	Marinas	71394	Marinas

The second phase, known as Storm Water Phase II, was signed by EPA in October 1999 and published in the *Federal Register* on December 8, 1999. The Phase II Rule will bring many municipal separate storm sewer systems serving fewer than 100,000 people, census districts in counties with population densities greater than 1,000 per square mile, and small construction sites of between 1 and 5 acres into the NPDES permitting program by March 2003. Construction sites where more than 1 acre is disturbed will need to obtain a permit and implement BMPs to minimize erosion and pollutant runoff. The rule exempts from regulation facilities that have industrial materials or activities that are not exposed to rain or snow. The Storm Water Rule and further information on Phases I and II of the Storm Water Program can be obtained from EPA's web site for the point source permitting program: http://cfpub1.epa.gov/npdes.

Removal of TSS at the 80 percent level is practicable, and the management practices mentioned here, or combinations of them, can achieve this degree of pollutant removal if they are designed properly and the site is suitable for their installation and use. The 80 percent level also provides a high degree of protection for surface waters. Used properly, pollutant removal management practices can also reduce final TSS concentrations in runoff very effectively. Table 4-3 reviews the pollutant removal efficiencies of many storm water control practices. Tables in Appendix F compare the advantages and disadvantages of many storm water control practices and their costs.

The 80 percent removal of TSS is recommended for hull and engine maintenance areas, the runoff from which often contains higher levels of toxic pollutants than runoff from other parts of a marina property. Pollutants in runoff from the remaining marina property should be considered when designing an effective runoff pollution prevention system. If sufficient land area is not available on-site to install runoff systems, management practices that increase vegetative cover, reduce impervious surfaces, and include infiltration devices are practical solutions.

The principal pollutants in runoff from marina parking areas and hull maintenance areas are suspended solids (paint chips, sanding dust, and the like.) and organics (predominately oil and grease). Toxic metals (in antifoulant paints) from boat hull scraping and sanding tend to attach themselves to suspended soil particles and are carried to the marina basin with the particles.

Designing and operating a hull maintenance work area with a focus on pollution prevention is an excellent way to prevent dangerous pollutants from reaching the marina basin. Particularly effective practices are designating a specified area that has an impervious surface (cement, for example) for hull maintenance work; doing all hull maintenance work under a roof to prevent the area from getting wet; and channeling and draining runoff from other areas of the marina property away from hull maintenance areas so it won't pick up the pollutants associated with hull maintenance. Devices with controls that collect pollutants as they are produced, such as vacuum-based (or dustless) sanders, are also effective for preventing pollutants from entering runoff.

Pollutants can also be trapped, collected, or filtered after they are on the ground but before it rains. This can be accomplished by using street

Table 4-3. Effectiveness of management practices for runoff control (adapted from Caraco and Winer, 2000).

Runoff Treatment or Control Practice Category or Type	Median Pollutant Removal (Percent)							
	No. of Studies	TSS	TP	OP	TN	NOx	Cu	Zn
Quality Control Pond	3	3	19	N/A	5	9	10	5
Dry Extended Detention Pond	6	61	20	N/A	31	-2	29	29
Dry Ponds	9	47	19	N/A	25	3.5	26	26
Wet Extended Detention Pond	14	80	55	69	35	63	44	69
Multiple Pond System	1	91	76	N/A	N/A	87	N/A	N/A
Wet Pond	28	79	49	39	32	36	58	65
Wet Ponds	43	80	51	65	33	43	57	66
Shallow Marsh	20	83	43	66	26	73	33	42
Extended Detention Wetland	4	69	39	59	56	35	N/A	-74
Pond/Wetland System	10	71	56	37	19	40	58	56
Submerged Gravel Wetland	2	83	64	14	19	81	21	55
Wetlands	36	76	49	48	30	67	40	44
Organic Filter	7	88	61	30	41	-15	66	89
Perimeter Sand Filter	3	79	41	68	47	-53	25	69
Surface Sand Filter	7	87	59	N/A	31.5	-13	49	80
Vertical Sand Filter	2	58	45	21	15	-87	32	56
Bioretention	1	N/A	65	N/A	49	16	97	95
Filtering Practices[a]	18	86	59	*57*	38	-14	49	88
Infiltration Trench	3	100	42	100	42	82	N/A	N/A
Porous Pavement	3	95	65	10	83	N/A	N/A	99
Ditches[b]	9	31	-16	N/A	-9	24	14	0
Grass Channel	3	68	29	32	N/A	-25	42	45
Dry Swale	4	93	83	70	92	90	70	86
Wet Swale	2	74	28	-31	40	31	11	33
Open Channel Practices	9	81	34	*1.0*	*84*	31	51	71
Oil-Grit Separator	1	-8	-41	40	N/A	47	-11	17

Shaded rows show data for groups of practices (e.g., dry ponds includes quality control ponds and dry extended detention ponds).
Numbers in italics are based on fewer than five data points.
[a] Excludes vertical sand filters
[b] Refers to open channel practices not designed for water quality.
TSS = total suspended solids, TP = total phosphorus, OP = ortho-phosphorus, TN = total nitrogen, NOx = nitrate and nitrite nitrogen, Cu = copper, Zn = zinc.

sweepers and vacuums that collect debris from the ground, placing tarps under boats while they are being sanded or painted, and planting grass buffers around hull maintenance areas, parking lots, sidewalks, and other impervious surfaces where pollutants tend to accumulate. Grass buffers effectively filter runoff water before it reaches surface waters, and they are attractive landscape elements.

Covering areas that are not used for boat maintenance with a porous surface allows rainwater to filter into the ground and reduces the amount of runoff created on the marina property. Crushed gravel or concrete and low grassy areas interspersed around and within otherwise impervious areas (parking lots, for example) are surfaces that allow rainwater to infiltrate into the ground. Directing storm water to a grassed area instead of to drains, pipes, or cement channels is an effective way to prevent the pollutants in runoff from reaching the marina basin, regardless of whether the runoff originates from parking lots, hull maintenance areas, rooftops, or any other impervious surface.

Some marinas might need to pretreat storm water runoff before it is discharged to a local sewer system. Pretreating wastewater from hull cleaning (pressure washing) might also be needed. The state or local environmental agency should be contacted to determine any specific legal requirements for treatment before discharge.

The goal of 80 percent reduction in the load of total suspended solids (TSS) in storm water runoff recommended in this management measure is achieved by eliminating (by pollution prevention or source reduction) 80 percent of the total annual load of suspended materials produced in an average year of work. Most marinas use some management practices and are already collecting some or all of this 80 percent. Note that 80 percent of the TSS load cannot usually be eliminated during each storm because the efficiency of any means chosen to remove pollutants from storm water fluctuates above and below 80 percent for individual storms. The goal of the management measure is to control an average of 80 percent of the amount of TSS produced at a marina during any given year. Because no two marinas are the same, the storm water control management practices used to achieve this goal have to be chosen site-specifically for each marina.

The annual TSS load baseline can be calculated as follows:

- Assume that marina operations are being conducted as usual, except that no management practices are used to collect pollutants from hull maintenance areas. All of the sanding dust, paint chips, and so forth produced fall to the ground.
- Given this scenario, add together the total amount of solid pollutants, such as paint chips and sanding dust, that would be swept away in runoff during storms that occur over a 1-year period and that are less than or equal to the 2-year/24-hour storm for the area. Solids carried away in snowmelt runoff should also be included.
- Multiply this quantity by 80 percent (0.80) to obtain the target minimum quantity of solid pollutants to be removed from storm water runoff and prevented from reaching the marina basin or storm drain.

This calculation can be complicated, primarily because of the difficulty in measuring the quantity of pollutants produced at a marina. The state or local environmental agency can be contacted for additional storm water guidance and for information pertaining to storm water regulations.

Applicability

This management measure is applicable to new and expanding marinas and to existing marinas at a minimum at hull maintenance areas.

Best Management Practices

♦ *Perform as much boat repair and maintenance work as possible inside work buildings.*

Sandblasting is best performed in a place where the debris produced is prevented from drifting to surrounding areas and being swept away in storm water runoff. One of the simplest and most effective ways to prevent pollutants from boat repairs from entering storm water runoff is to

perform as much work as possible under roofs or in enclosures. Performing maintenance work in a fully enclosed building protects the work area from wind and contains the dust and debris produced during the work so it is much easier to clean up afterward.

♦ *Where an inside work space is not available, perform abrasive blasting and sanding within spray booths or tarp enclosures.*

The inside of a building provides the most protected space, but if a large enough interior space is not available, a suitably sized area can be protected with tarps or temporary plastic buildings can be used. Tarps help prevent residue from drifting to nonwork areas of the marina and into surface waters. Scheduling work on calm days helps ensure that wind won't carry debris and pollutants to other areas of the marina property and the marina basin.

♦ *Where buildings or enclosed areas are not available, provide clearly designated land areas for boat repair and maintenance.*

If a facility is large enough, one or more sections of the yard, ideally located well away from the shore, can be designated for boat repairs and maintenance (Figure 4-8). Mark the area well with signs, post a list of boat owner responsibilities, indicate the rules for use of the work area, and do not permit work outside the designated areas. Areas where abrasive work will be performed should be protected from wind and enclosed if possible. This practice should help the marina property stay relatively clean. Where possible, inland areas, away from surface waters, should be used for boat repair work.

♦ *Design hull maintenance areas to minimize contaminated runoff.*

Hull maintenance areas can be located indoors or outdoors, and activities that produce a large amount of polluting debris can be conducted over a dry, impervious surface like a cement pad. Other portable, temporary ground covers like tarps can also be effective. Such a surface makes it easy to collect and properly dispose of debris, residues, solvents, and spills before they enter storm water runoff.

Figure 4-8. Conanicut Marine Service (Rhode Island) found that purchasing land almost a mile from the shore and using a hydraulic boat trailer was significantly less expensive than purchasing waterfront property, and doing so allowed expansion of its service work to an inland boatyard. No coastal permits were needed for the inland yard, and the risk of water pollution from runoff from the yard was significantly reduced (USEPA, 1996: *Clean Marinas—Clear Value*).

♦ *Use vacuum sanders both to remove paint from hulls and to collect paint dust and chips.*

Vacuum sanders have proven very effective at capturing paint dust and chips during boat hull and bottom sanding. Immediate capture prevents paint dust and chips from entering the marina basin, makes cleaning up the work area easier. It also increases the speed at which a boat bottom can be completely sanded.

Such sanders capture up to 98 percent of the dust generated. Workers do not have to wear full suits with respirators. They use fewer disk pads and have less cleanup to perform in surrounding areas. Vacuum-based sanders are increasingly being used in boatyards and marinas, and they might be available for rental by boat owners who want to sand their own hulls. Many marinas have converted to dustless sanders and require that they be used by customers and outside contractors. In addition to preventing pollution, using vacuum sanders can dramatically increase the efficiency of sanding operations.

The results of a BMP demonstration project at five Rhode Island marinas showed that several techniques can make the use of vacuum sanders more effective. First, the availability of the machinery needs to be publicized with flyers or

signs in hull maintenance areas. Second, staff should be well trained and ready to inform customers that a professional vacuum sander is available for use and how to use it properly. Users need to be given complete operating instructions and must clearly understand them before using the machine.

♦ *Restrict the types and/or amount of do-it-yourself work done at the marina.*

Largely for environmental liability reasons, an increasing number of marina owners are restricting do-it-yourself boat repair work of the "dirty" kind, such as exterior sanding and painting. A small but increasing percent of marinas are prohibiting such repairs on-site unless done by a professional who is trained in, understands, and follows state-approved environmental management practices.

♦ *Clean hull maintenance areas immediately after any maintenance to remove debris, and dispose of collected material properly.*

Cleaning hull maintenance areas immediately after maintenance or repair work is done removes trash, visible paint chips, and other debris before they can be blown or washed into the marina basin. Spent sandblasting grit, boat repair debris, and solid waste should be stored under cover and in a manner that minimizes contact with process or storm water. Vacuuming or sweeping is an excellent method of collecting these wastes, especially over paved surfaces. Hosing a maintenance area for cleanup can result in the same pollution that storm water would cause.

♦ *Capture and filter pollutants out of runoff water with permeable tarps, screens, and filter cloths.*

Tarpaulins can be placed on the ground, before a boat is placed in a cradle or stand for sanding and painting. The common plastic tarpaulins collect paint chips, sanding dust, and paint drippings, which then can be collected and disposed of into dumpsters with other solid trash, as permitted by local or state ordinances. Impermeable plastic tarps, however, have their drawbacks. Wind easily blows dust and chips off the tarps, and rainwater washes debris from the tarps. Semipermeable filter cloths can be more effective than solid cloth or plastic tarps for collecting debris where wind is a problem, where tarps are not always cleaned each day after work is completed, or where work is continued during light rains. The filter cloths hold onto debris better and allow water to pass through while retaining debris for later disposal.

♦ *Sweep or vacuum around hull maintenance areas, roads, and driveways frequently.*

Frequent vacuuming of impervious areas can effectively prevent pollutants from reaching the marina basin and nonmaintenance areas of the marina property. Scheduling vacuuming (e.g., once a day or every other day during the boating season) and adhering to the schedule helps make this a particularly effective management practice. The practice is most effective in hull maintenance areas if the surface under any boat being worked on is swept at the end of each workday.

♦ *Sweep parking lots regularly.*

Cars, trucks, commercial vehicles, and foot traffic carry a lot of sand, grit, and dirt to parking lots. Gum wrappers, paper and styrofoam cups, cigarette butts, and cellophane wrappings tend to end up on parking lot pavement as well. Storm water carries these pollutants to the marina basin or to drain inlets, catch basins, and oil/grit separators. Regular parking lot sweeping helps reduce the amount of sand, grit, and trash that reaches the marina basin and storm water controls. Because catch basins and oil/grit separators require periodic cleaning for efficient operation, sweeping the parking lot extends the time between sweepings.

♦ *Plant grass between impervious areas and the marina basin.*

Grass retains and filters pollutants from runoff. A well-maintained lawn that is located between impervious surfaces (e.g., parking lots) and the marina basin and to which runoff from the impervious surface is directed increases rainwater infiltration and creates an attractive marina environment (Figure 4-9).

The technical term for a channel or ditch planted with grass and used for storm water treatment is *grassed swale*. Grassed swales are low-gradient

Figure 4-9. Storm water runoff is controlled at Deep River Marina (Connecticut) by 50-foot-wide grass buffers and a parking lot that is covered with crushed rock and has sediment traps in the storm drains. Picnic tables and flowers in the lawn areas make the marina visually attractive and useful to families. Summerfield Boat Works (Florida) added an unpaved parking lot across the street from the main marina property and basin and landscaped its perimeter to blend in with the neighborhood. Harbour Towne Marina (Florida) reduced runoff contamination by planting a grass buffer around the perimeter of the facility. The facility's parking is largely paved and drains to the buffer strip, and the grass adds a cooling and visually pleasing element to the marina property (USEPA, 1996: *Clean Marinas—Clear Value*).

channels that can be used in place of buried storm drain pipes (Figure 4.10). To effectively remove pollutants, grassed swales need to have only a slight slope and should be long enough to allow all of the pollutants in storm water to be filtered out. Because storm water is directed to them and storms are occasionally very strong, erosion-resistant vegetation such as deep-rooted grasses works best. The vegetation filters out pollutants and absorbs nutrients from the storm water, and runoff infiltrates into the ground as it is slowed by the grass in the swale. Grassed swales are best used in conjunction with other practices listed under this management measure.

♦ *Construct new or restore former wetlands where feasible and practical.*

If space and economy permit, consider restoring wetland vegetation that might have formerly existed at the edge of the marina basin or altering a portion of the basin perimeter to support wetland vegetation. Wetlands are extremely efficient at removing pollutants from water.

♦ *Use porous pavement where feasible.*

Pervious pavement has strength characteristics approximately equal to those of traditional pavement but allows rainfall and runoff to percolate through it. The key is the elimination of most of the fine aggregate found in conventional pavements. There are two types of pervious pavement, porous asphalt and pervious concrete. Porous asphalt has coarse aggregate held together in the asphalt with sufficient interconnected voids to yield high permeability. Pervious concrete, in contrast, is a discontinuous mixture of Portland cement, coarse aggregate, admixtures, and water that also yields interconnected voids for the passage of air and water. Underlying the pervious pavement are a filter layer, a stone reservoir, and a filter fabric. Stored runoff gradually drains out of the stone reservoir into the subsoil.

A porous surface can also consist of a coarse, permeable top layer covering an additional layer of gravel (Figure 4-11). Runoff infiltrates through the porous layer and into the ground. As storm water passes through the pavement, the gravel, and perhaps a perforated underground pipe system and then into the underlying soil, pollutants are naturally filtered out. Porous pavement helps recharge ground water and provides excellent pollutant removal (up to 80 percent of sediment, trace metals, and organic matter).

Other types of porous pavements might be suitable for walkways and areas that will not be subjected to heavy loads.

♦ *Install oil/grit separators and/or vertical media filters to capture pollutants in runoff.*

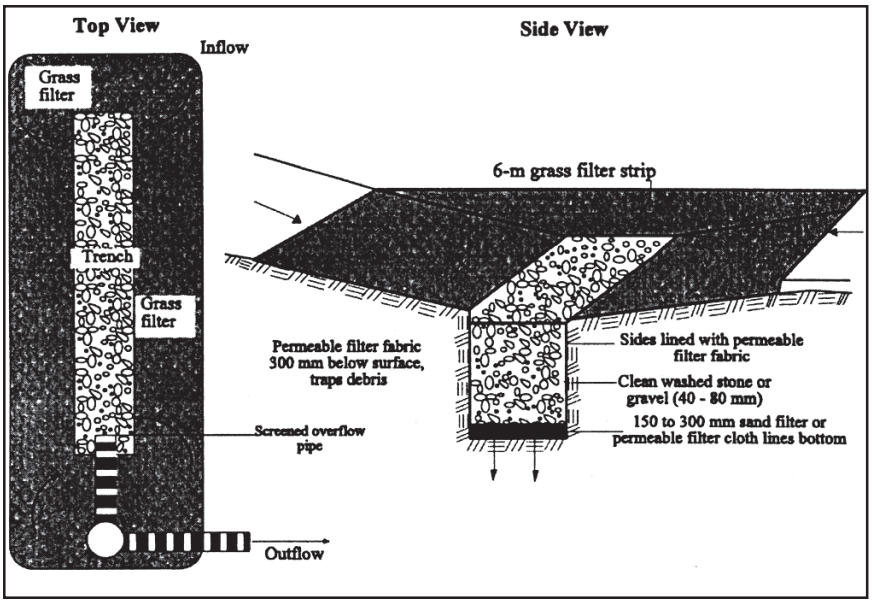

Figure 4-10. Grassed filter strip surrounding an infiltration trence (adapted from Schueler, 1987).

Oil/grit separators are useful where petroleum is spilled or could be spilled (Figure 4-12). Oil/grit separators can be used to treat water from small areas where other measures are infeasible. They are particularly applicable where the work performed contributes large loads of grease, oil, mud, or sand to runoff. Inspection and maintenance should occur at least twice per year or per the manufacturer's recommendations. With proper maintenance, oil/grit separators can last 50 years.

Vertical media filters use passive filtration to remove many pollutants from storm water. The pollutants removed include sediment, nutrients, soluble metals, hydrocarbons, trash, and debris. The filters are typically installed in high-use parking lots, industrial parking lots, roads, bridge decks, and multiple-use areas. A variety of filter media can be installed to capture different pollutants, and the number of filter media used can be adjusted, permitting the user to adapt the installation to the requirements of the specific location.

♦ *Use catch basins where storm water flows to the marina basin in large pulses.*

Catch basins with flow restrictions are used to prevent large pulses of storm water from entering the marina basin at one time. Particulates and soil settle to the bottom of a catch basin, in which the bottom of the basin is typically 2 to 4 feet below the outlet pipe (the pipe through which the trapped water is allowed to escape). The traps in a catch basin require periodic cleaning and maintenance, but if properly maintained, a catch basin should have a life span similar to that of oil/grit separators (50 years).

Catch basins can have a separate chamber filled with sand. With this design, runoff first enters an open chamber where coarse particles that could clog the sand are filtered out. The runoff then flows into a second chamber where other pollutants are filtered out by infiltrating through the sand. Catch basins with sand filters are effective in highly impervious areas, where other practices have limited usefulness. They need to be inspected at least annually, and the top layer of sand should be removed periodically and replaced with fresh, clean sand.

Figure 4-11. Lockwood Boat Works (New Jersey) regraded its combined parking and boat maintenance yard and surfaced it with 6 inches of crushed concrete to successfully control runoff. Using recycled concrete crushed into stone-sized pieces, the cost was $18,000 per acre installed, whereas crushed rock would have cost $27,000 per acre and asphalt paving would have cost $54,000 per acre (USEPA, 1996: *Clean Marinas—Clear Value*).

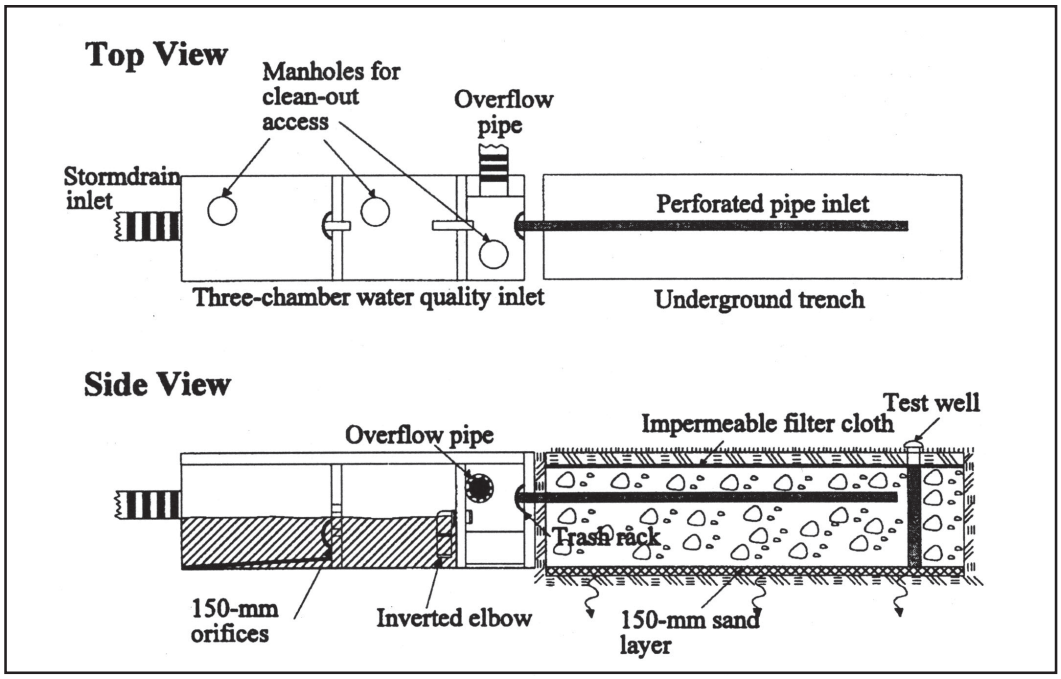

Figure 4-12. Underground trench with oil/grit chamber (adapted from Schueler, 1987).

♦ *Add filters to storm drains that are located near work areas.*

Some storm drain designs permit insertion of a filter to screen solid materials out of runoff. If oil is typically contained in runoff, an oil absorption pad can be inserted into the water pool or trap beneath the filter as well. Filters and absorption pads placed in storm drains must be cleaned or replaced regularly to function properly.

♦ *Place absorbents in drain inlets.*

Oil and grease are not ordinarily captured by catch basins. An absorbent material placed in a drain where it will intercept storm water can remove much of the oil and grease contained in runoff. Absorbent material products can remove 10 to 25 times their weight in oil. Absorption pads placed in drain inlets must be cleaned or replaced regularly to function properly.

♦ *Use chemical and filtration treatment systems only where necessary.*

Wastewater can be treated by the addition of certain chemicals that cause small solid particles to adhere together to form larger particles, which are then filtered from the water. This type of treatment system can remove more than 90 percent of the suspended solids and 80 percent of most toxic metals associated with hull pressure-washing wastewater. The degree of treatment is determined by how much of the chemical is added and the porosity of the filter used, and it can be altered to meet municipal standards. Because the chemicals used for this type of treatment require disposal themselves, this method of pollutant removal is suggested for use only where other methods prove ineffective. This type of treatment system might be regulated by the state or local environmental authority, and any regulatory restrictions for its use should be determined before choosing to use it.

BMP Summary Table 5 summarizes the BMPs for Storm Water Runoff control mentioned in this guidance.

BMP Summary Table 5. STORM WATER RUNOFF MANAGEMENT

MANAGEMENT MEASURE: Implement effective runoff control strategies that include the use of pollution prevention activities and the proper design of hull maintenance areas. Reduce the average annual loadings of total suspended solids (TSS) in runoff from hull maintenance areas by 80 percent. For the purposes of this measure, an 80 percent reduction of TSS is to be determined on an average annual basis.

APPLICABILITY: New and expanding marinas, and existing marinas at a minimum at hull maintenance areas.

ENVIRONMENTAL CONCERNS: Sanding dust, paint dust and chips, copper and other heavy metals, and other such solids that drop on the ground during boat repair and maintenance can all be swept into the water by the next rainstorm's runoff. Oils, grease, solvents, paint drippings, and fuel spilled or dripped onto the ground are also be carried away in runoff. Unless runoff is treated in some manner, all of these pollutants will end up in the marina basin, where they will create unsightly surface films or float until they adhere to a surface like a boat hull. Some of these pollutants can sink to the bottom soil, where they can be eaten by bottom-feeding fish or filter-feeding shellfish, or settle onto the leaves of aquatic vegetation and clog their pores.

STORM WATER RUNOFF MANAGEMENT PRACTICES

Best Management Practice Examples	Marina Location & Usage	Benefits to Marina	Projected Environmental Benefits	Initial Cost Estimate	Annual Operation & Maintenance Cost Estimate	Notes
Perform as much boat repair and maintenance work as possible inside work buildings	Boat maintenance area; universally recommended	MODERATE to HIGH; protects the work area from wind and rain; contains dust and debris for easier cleanup	MODERATE to HIGH; simple and effective way to prevent pollutants from entering storm water runoff	LOW if building exists to EXPENSIVE for new building	MODERATE	Temporary plastic buildings can be used
Where an inside work space is not available, perform abrasive blasting and sanding within spray booths or tarp enclosures	Boat maintenance area; universally recommended	MODERATE to HIGH; protects the work area from wind and rain; contains dust and debris for easier cleanup	MODERATE to HIGH	MODERATE	MODERATE	Schedule work on calm days to help ensure that debris and pollutants are not carried to other areas of the marina property and the marina basin
Where buildings or enclosed areas are not available, provide clearly designated land areas for boat repair and maintenance	Hull maintenance in designated upland areas; generally recommended	MODERATE; keeping all work in one area helps control pollutants	HIGH; keeping the work away from the water is an effective way to protect water quality	LOW to MODERATE	LOW to MODERATE	Protect from wind and capture debris using one of the BMPs mentioned (tarp, filter cloth, etc.)
Design hull maintenance areas to minimize contaminated runoff	Boat maintenance area; universally recommended	MODERATE to HIGH; debris collection and cleanup are easier when appropriate controls are in place	HIGH; decreases possibility that maintenance debris will enter waterbody with runoff	MODERATE to HIGH	MODERATE	Construct hull mainten-ance areas with an impervious surface like cement; mark the boundaries of maintenance areas with clear visible signs.

BMP Summary Table 5. (cont.) STORM WATER RUNOFF MANAGEMENT

Best Management Practice Examples	Marina Location & Usage	Benefits to Marina	Projected Environmental Benefits	Initial Cost Estimate	Annual Operation & Maintenance Cost Estimate	Notes
Use vacuum sanders both to remove paint from hulls and to collect paint dust and chips	Hull maintenance areas; universally recommended	HIGH; perhaps the most efficient and effective practice; easy to use; saves cost of cleanup, improves quality and speed of hull work	HIGH; 98% effective at keeping sanding dust out of environment	LOW to MODERATE per unit	LOW per unit	Rental fee income can defray capital cost; vacuum sanders are desirable but not effective for some tasks
Restrict the types and/or amount of do-it-yourself work done at the marina	Hull maintenance areas; generally recommended	MODERATE; reduces debris production, non-compliance with marina rules, and staff time spent cleaning up	MODERATE; reduces debris produced at hull maintenance areas and surface water pollution	LOW	LOW	Do-it-yourself work can be appropriate where users first are thoroughly educated in pollutant reduction and privileges can be revoked for non-compliance. Restrict the types and/or amount of do-it-yourself work done at the marina
Clean hull maintenance areas immediately after any maintenance to remove debris, and dispose of collected material properly	Hull maintenance areas; universally recommended	MODERATE; daily cleaning of work areas reduces accidents, improves work quality, and increases customer satisfaction	MODERATE; reduces amount of maintenance debris and litter blowing around marina and into the water; sweeping keeps litter and sand out of storm drains	LOW	MODERATE	Minimize use of hose water for cleaning grounds because pollutants can be carried in the runoff
Capture and filter pollutants out of runoff water with permeable tarps, screens, and filter cloths	Upland and indoor maintenance areas; generally recommended	MODERATE; debris is more easily collected and disposed of into dumpsters with other solid trash, as permitted by local or state ordinances; inexpensive, reusable materials	MODERATE to HIGH for semipermeable filter cloths; LOW for impermeable plastic tarps	LOW	LOW	Where heavily used, tarps need daily cleaning and are subject to wind blowing and rain runoff; semipermeable filter cloth tarps are better
Sweep and/or vacuum around hull maintenance areas, roads, and driveways frequently	Marina upland areas; universally recommended	HIGH to MODERATE; sweeping reduces the need to clean the basin; keeps marina attractive	MODERATE to HIGH; regular sweeping keeps sand, grit, and debris out of surface waters	LOW; HIGH if mobile sweeper purchased	MODERATE	Clean grounds encourage boaters to keep the marina and waters clean
Sweep parking lots regularly	Marina parking lots and roads; universally recommended	HIGH to MODERATE; sweeping the parking lot will extend the time between cleanings of catch basins and oil/grit separators; keeps marina attractive	MODERATE to HIGH; regular sweeping keeps litter and sand out of storm drains and the water	LOW; HIGH if mobile sweeper purchased	MODERATE	Particularly important for porous pavement

BMP Summary Table 5. (cont.) STORM WATER RUNOFF MANAGEMENT

Best Management Practice Examples	Marina Location & Usage	Benefits to Marina	Projected Environmental Benefits	Initial Cost Estimate	Annual Operation & Maintenance Cost Estimate	Notes
Plant grass between impervious areas and the marina basin	Between marina work and parking areas and shoreline; generally recommended	HIGH; creates an attractive buffer, which add good appearance; if wide enough, can serve as recreation area for boaters	HIGH; lawn grass is a very effective buffer; retains and filters pollutants from runoff; absorbs nutrients from storm water; stabilizes the shore	MODERATE	MODERATE	A shallow ditch planted with grass and used for storm water treatment is a "grassed swale" regular maintenance is required
Construct new or restore former wetlands where feasible and practical	Shore and water edge; recommended where space allows	MODERATE to HIGH; wetlands are attractive shoreline habitat; attract customers	MODERATE to HIGH; wetlands are extremely efficient at removing pollutants from the water; act as natural buffers; reduce erosion	HIGH to EXPENSIVE	LOW to HIGH	Not suitable where land is limited; plantings can be hard to establish; but once established, require little or no maintenance
Use porous pavement where feasible	Marina parking lots and maintenance areas; generally recommended	HIGH to MODERATE; porous pavement can be cheaper than asphalt paving; reduced need for other elaborate/costly runoff control measures	HIGH; recharges ground water and provides excellent pollutant filtration through the ground	HIGH to EXPENSIVE	LOW to MODERATE	Suitable under certain conditions; requires frequent cleaning; not suitable for passage of heavy loads and equipment
Install oil/grit separators to capture petroleum spills and coarse sediment	Boat maintenance areas; generally recommended	MODERATE to HIGH; oil/grit separators should last 50 years with proper maintenance; minimal labor cost once installed	MODERATE to HIGH; efficient practice where the work performed contributes large loads of grease, oil, mud, sand, or trash to runoff	MODERATE per unit	LOW	Must be cleaned regularly; see manufacturer's specifications
Use catch basins where storm water flows to the marina basin in large pulses	Marina storm drains; recommended	MODERATE to HIGH; with proper maintenance, catch basins should last 50 years	HIGH; catch basins with sand filters are effective in highly impervious areas, where other practices have limited usefulness	HIGH	LOW	Traps of catch basins require periodic cleaning and maintenance
Add filters to storm drains that are located near work areas	Marina storm drains in work areas; generally recommended	MODERATE to HIGH; very low-cost; easy to get and replace; effectively filter out most large materials from runoff; simple and reliable	MODERATE to HIGH; screen larger solid materials out of water; not as effective for very small particles	LOW	LOW	Require periodic maintenance; held in place just below the drain cover

BMP Summary Table 5. (cont.) STORM WATER RUNOFF MANAGEMENT						
Best Management Practice Examples	**Marina Location & Usage**	**Benefits to Marina**	**Projected Environmental Benefits**	**Initial Cost Estimate**	**Annual Operation & Maintenance Cost Estimate**	**Notes**
Place absorbents in drain inlets	Marina storm drains and catch basins; generally recommended	MODERATE; oil pads and pillows absorb most petroleum products effectively; low cost and readily available; easy inspection and replacement	HIGH; remove much of the oil and grease from runoff; can remove 10 to 25 times their weight in oil from water	LOW	LOW	Absorbent materials need to be inspected regularly and changed periodically
Use chemical and filtration treatment systems only where necessary	Boatyard work and hull cleaning areas; recommended	LOW; very effective but very expensive practice	HIGH; these systems can remove in excess of 90% of suspended solids and 80% of most toxic metals from hull pressure-washing wastewater	HIGH to EXPENSIVE	HIGH to EXPENSIVE	Check with local or state environmental authority before installation because permits might be required